

# Why Is Mathematics Achievement Important?

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# Why should we care about mathematics achievement?

- Growing national concern about economy
  - Globalization
  - Out-sourcing & off-shoring
  - Rise of other nations
- Friedman: *The World is Flat*
  - 40+ weeks on the list of top selling books
  - Communicated the “message”

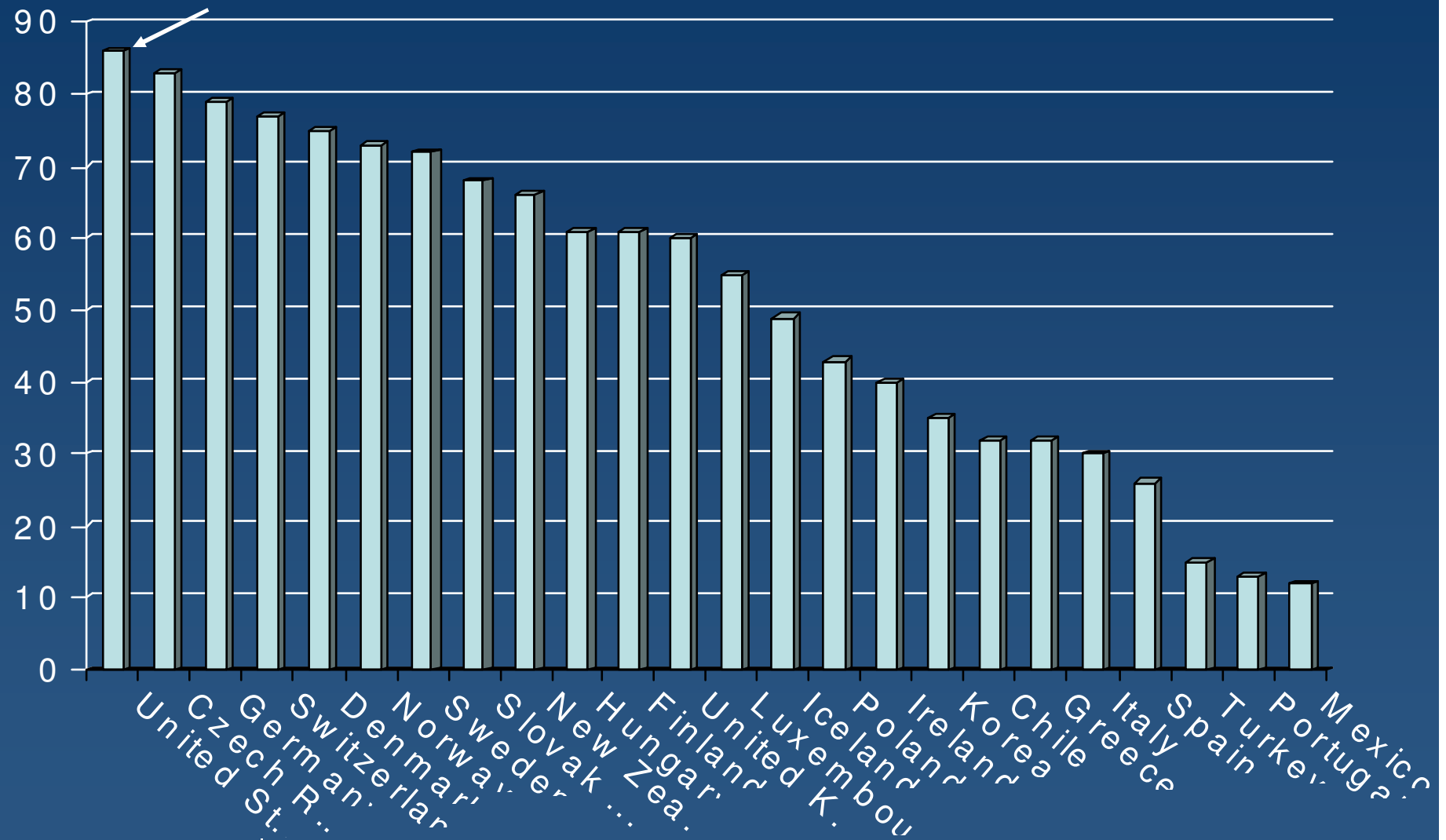
# Competitiveness Indicators

- The United States is today a net importer of *high-technology* products. Its trade balance in high-technology manufactured goods shifted from *plus* \$54 billion in 1990 to *negative* \$50 billion in 2001.
- Chemical companies closed 70 facilities in the United States in 2004 and tagged 40 more for shutdown. Of 120 chemical plants being built around the world with price tags of \$1 billion or more, one is in the United States and 50 are in China.
- In 2005, only four American companies ranked among the top 10 corporate recipients of patents granted by the *United States* Patent and Trademark Office.

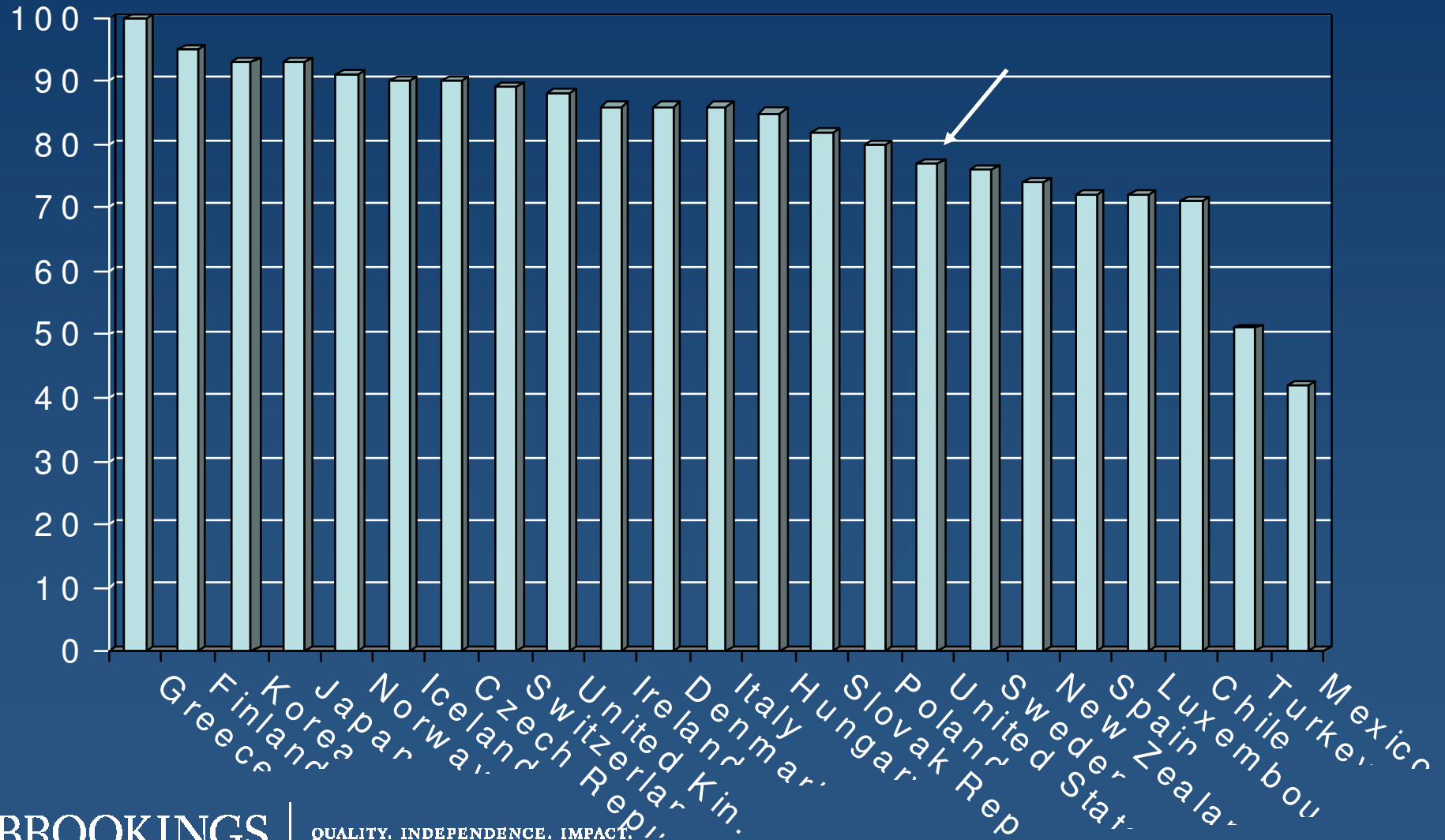
# More Competitiveness Indicators

- In South Korea, 38% of all undergraduates receive their degrees in natural science or engineering. In France, the figure is 47%, in China, 50%, and in Singapore 67%. In the United States, the corresponding figure is 15%.
- Some 34% percent of doctoral degrees in natural sciences and 56% of engineering PhDs in the United States are awarded to foreign-born students.
- In the U.S. science and technology workforce in 2000, 38% of PhDs were foreign-born

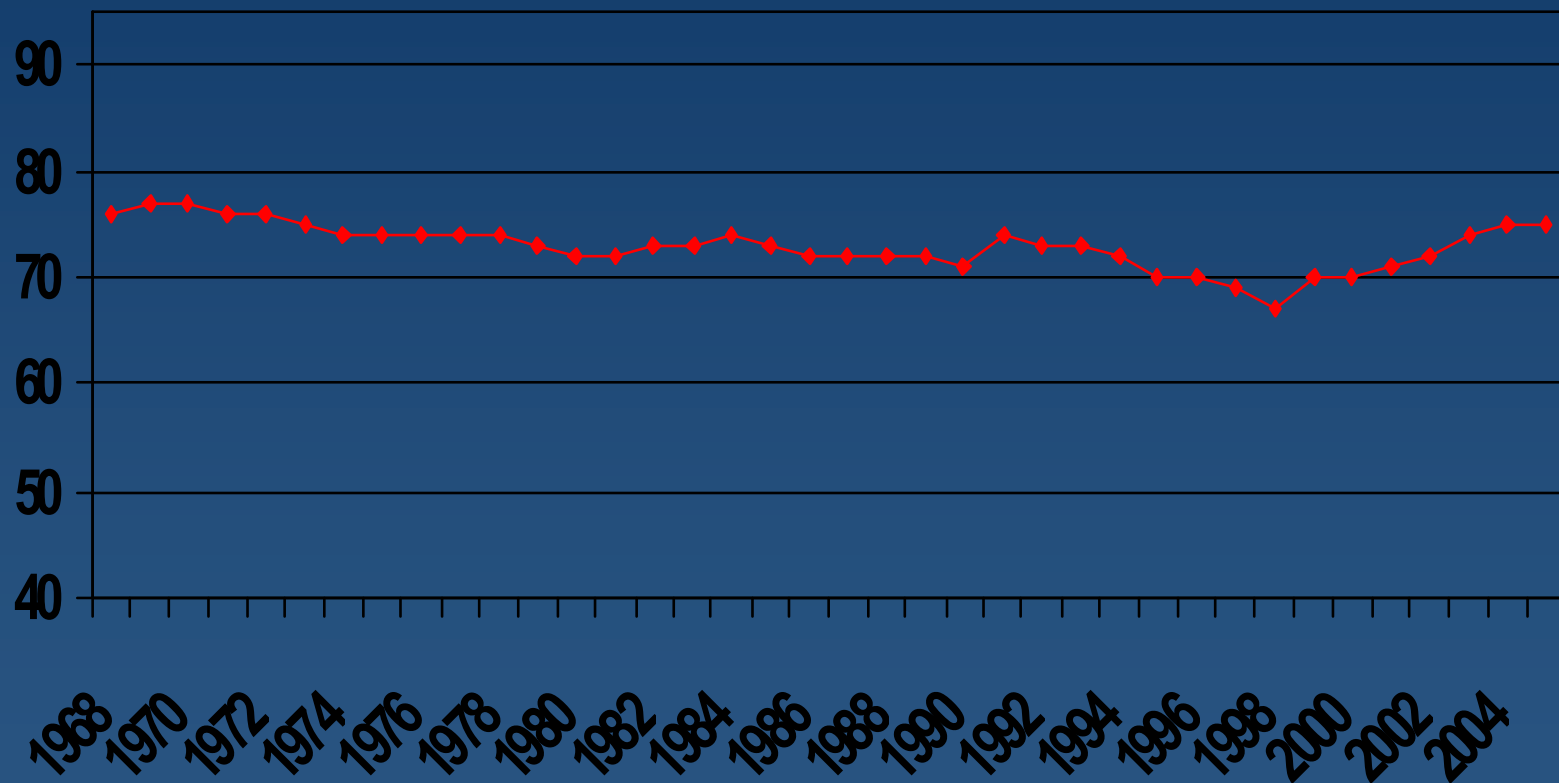
# % of high school grads to the population at the typical age of graduation 1960s



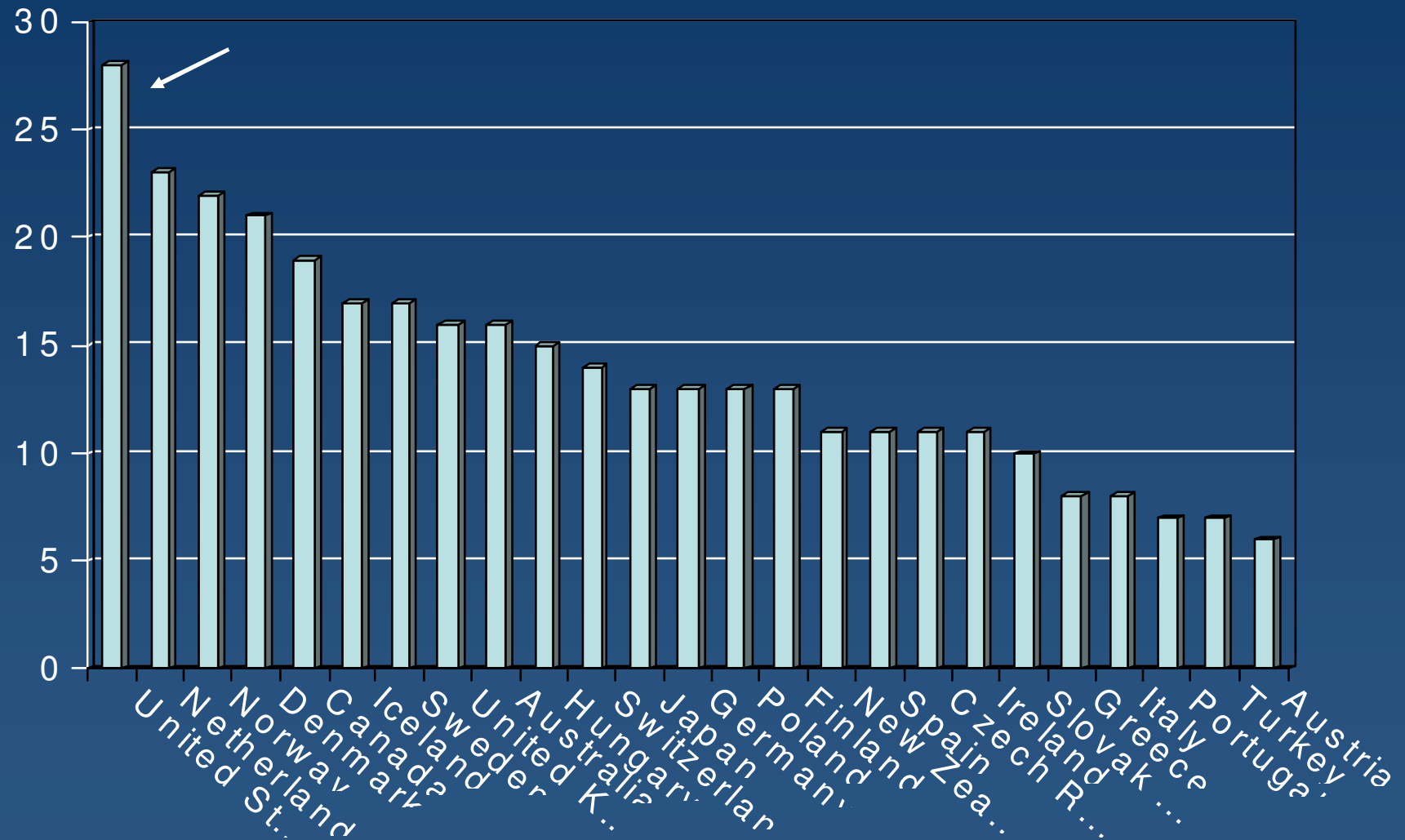
# % of high school grads to the population at the typical age of graduation 2006



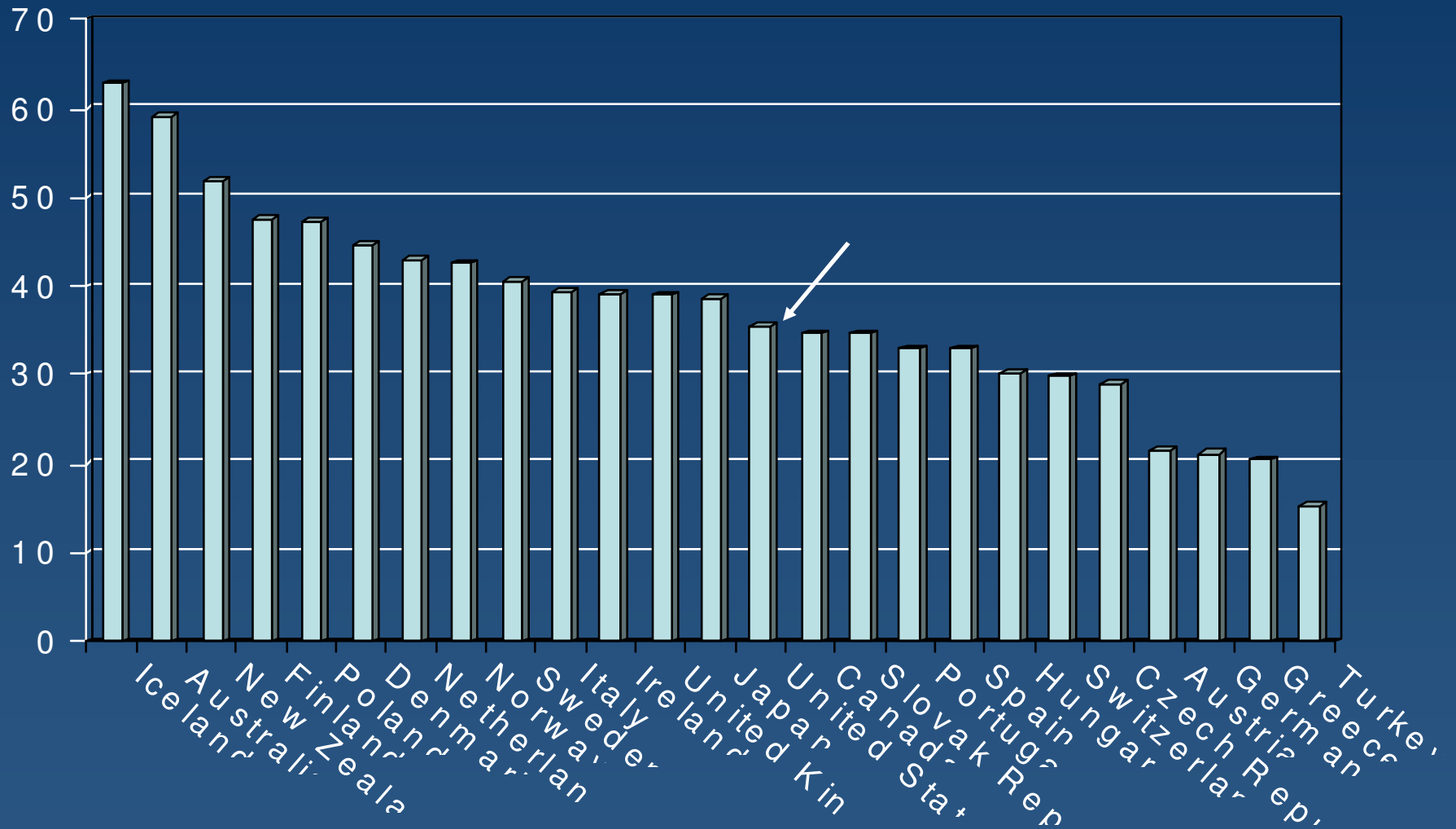
# 17-Year Old Graduation Ratio



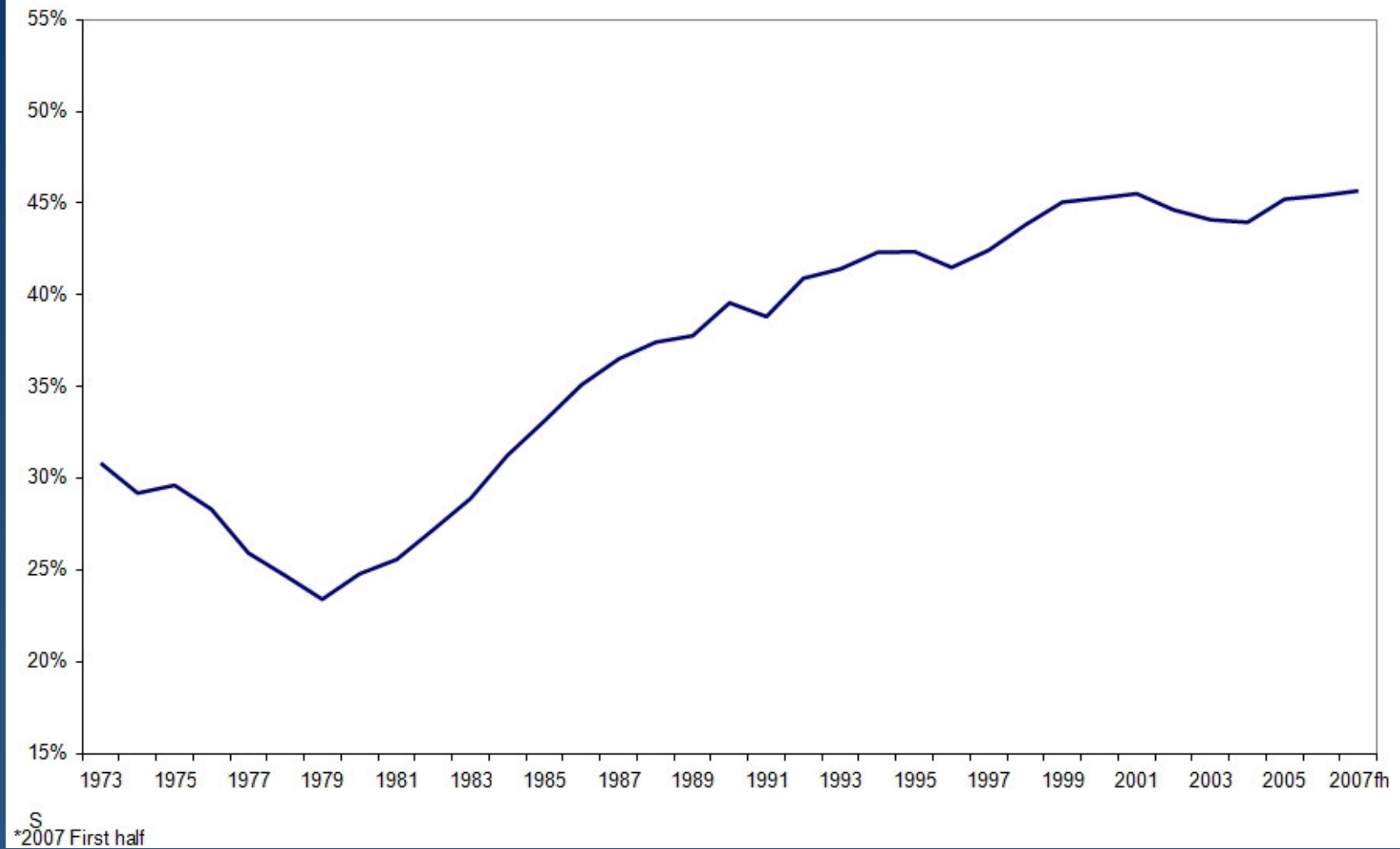
# % of postsecondary grads to the population at the typical age of graduation 1960s



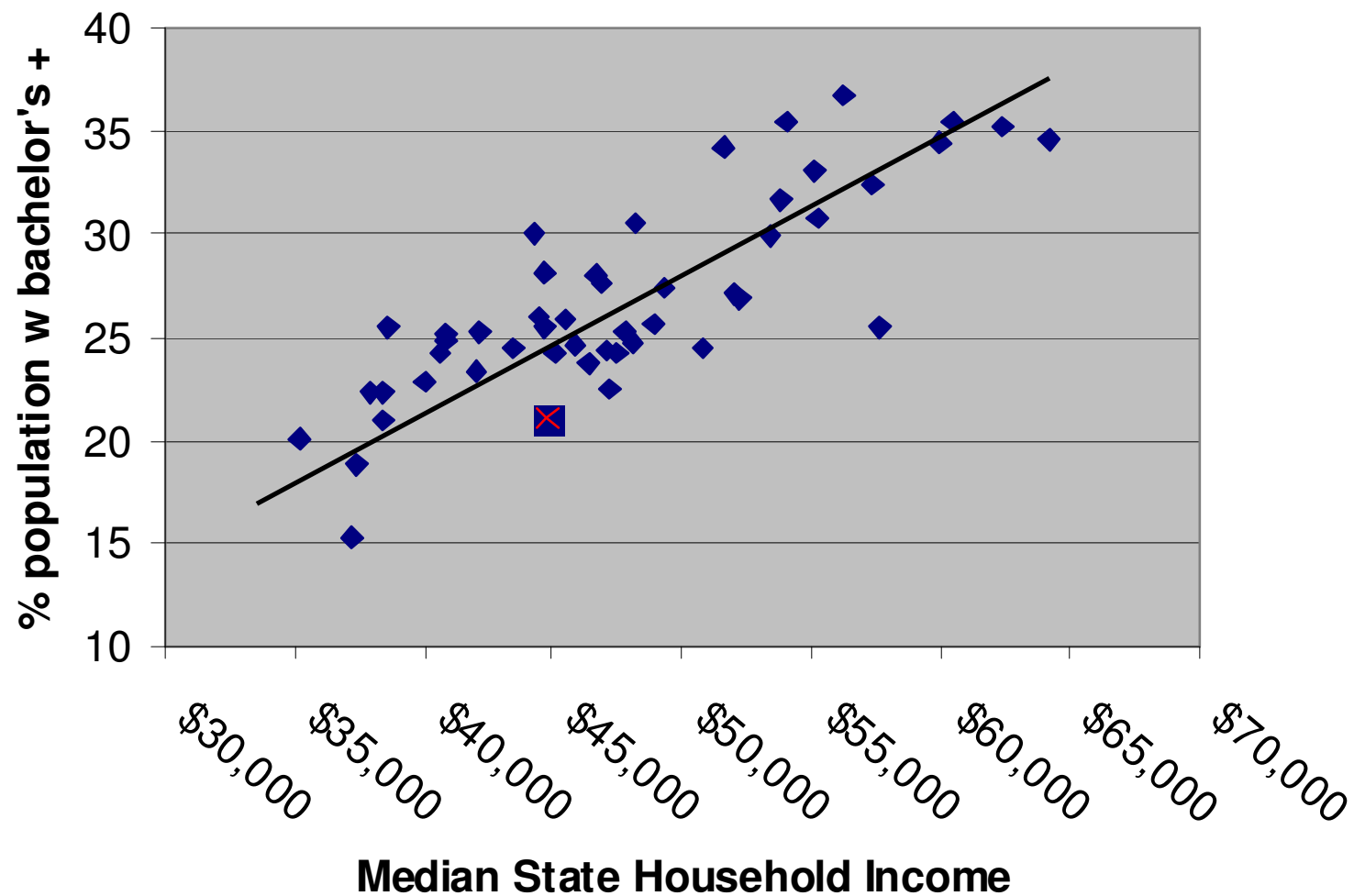
# % of bachelors and above to the population at the typical age of graduation 2006



Returns to Education:  
The College - High School Wage Premium, 1973-2007\*

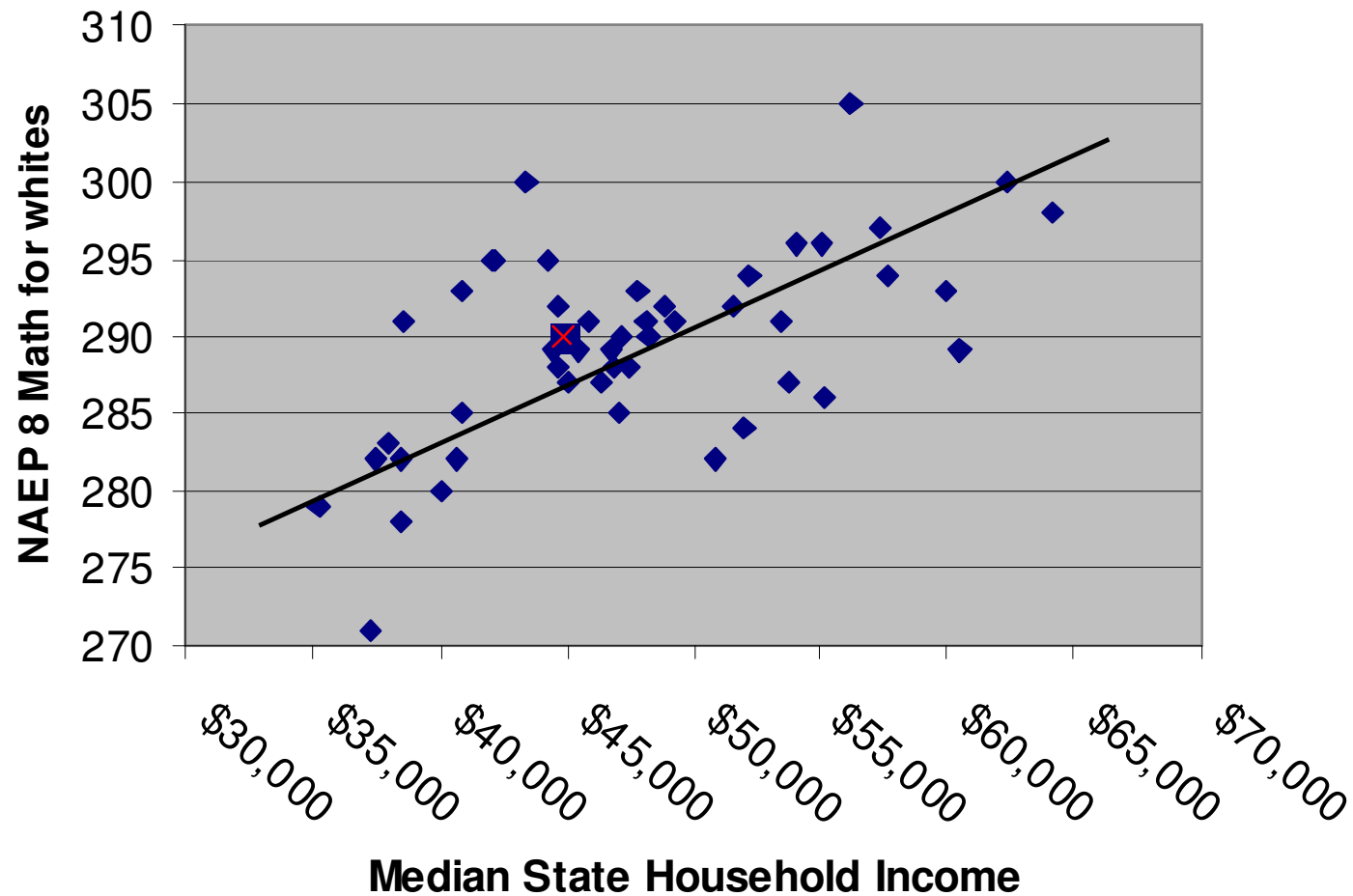


## Income and Education Attainment ( $r = .83$ )

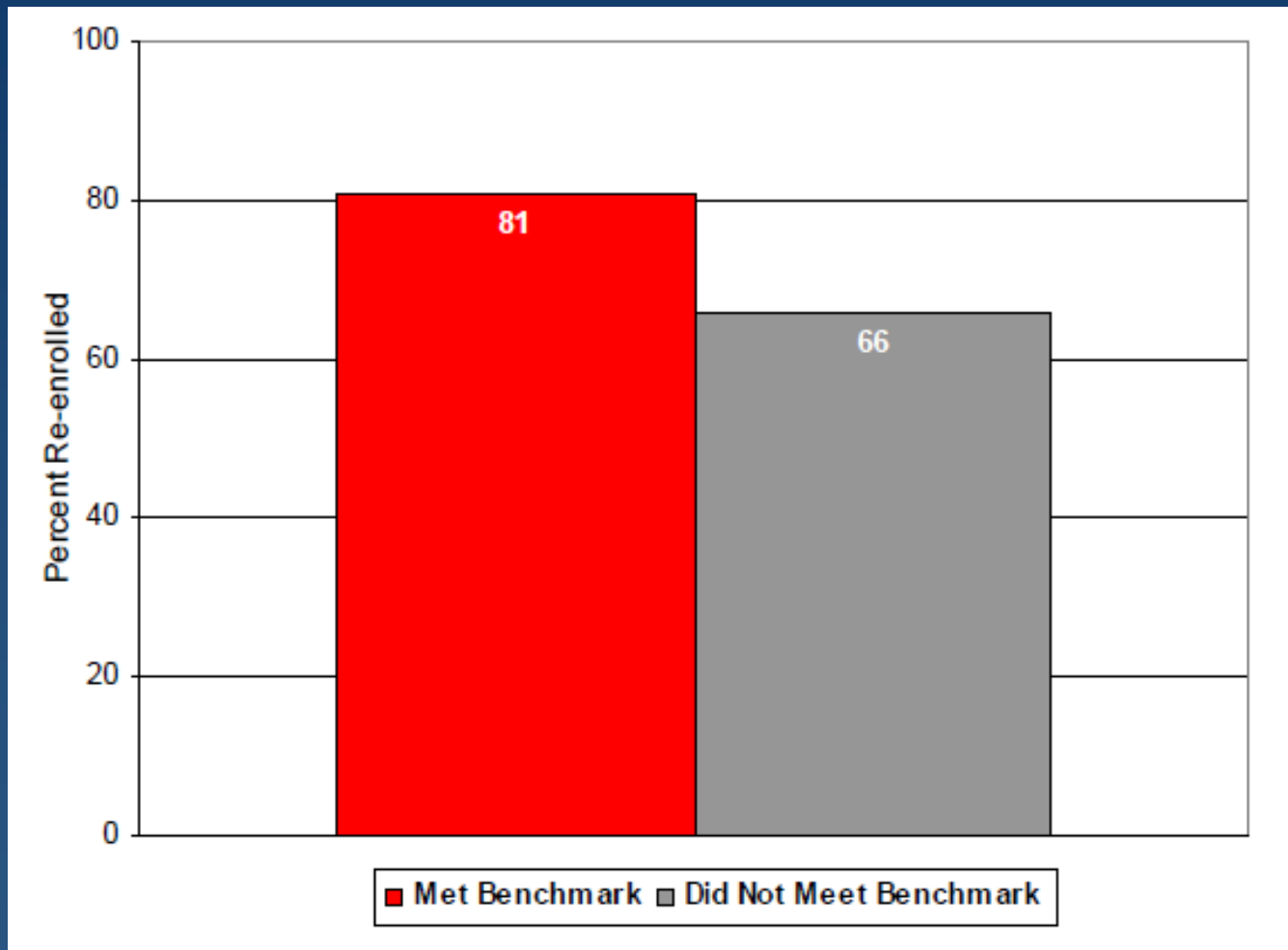


What does math have to do with it?

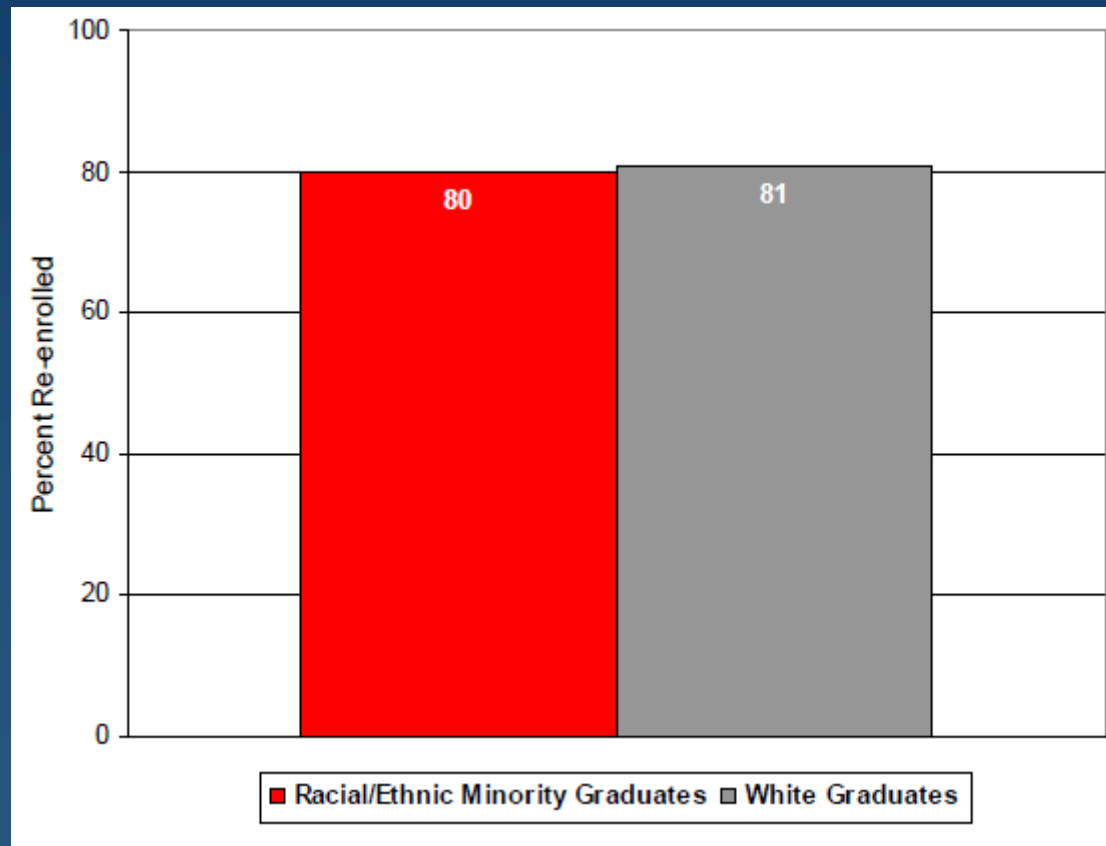
## Income and Middle School Math ( $r = .59$ )



# College Retention Rates for 2005 High School Grads by ACT College Readiness Benchmark Attainment in Math



# College Retention Rates for 2005 High School Grads Meeting ACT College Readiness Benchmark in Math, by Race/Ethnicity



# What predicts college performance in science courses?

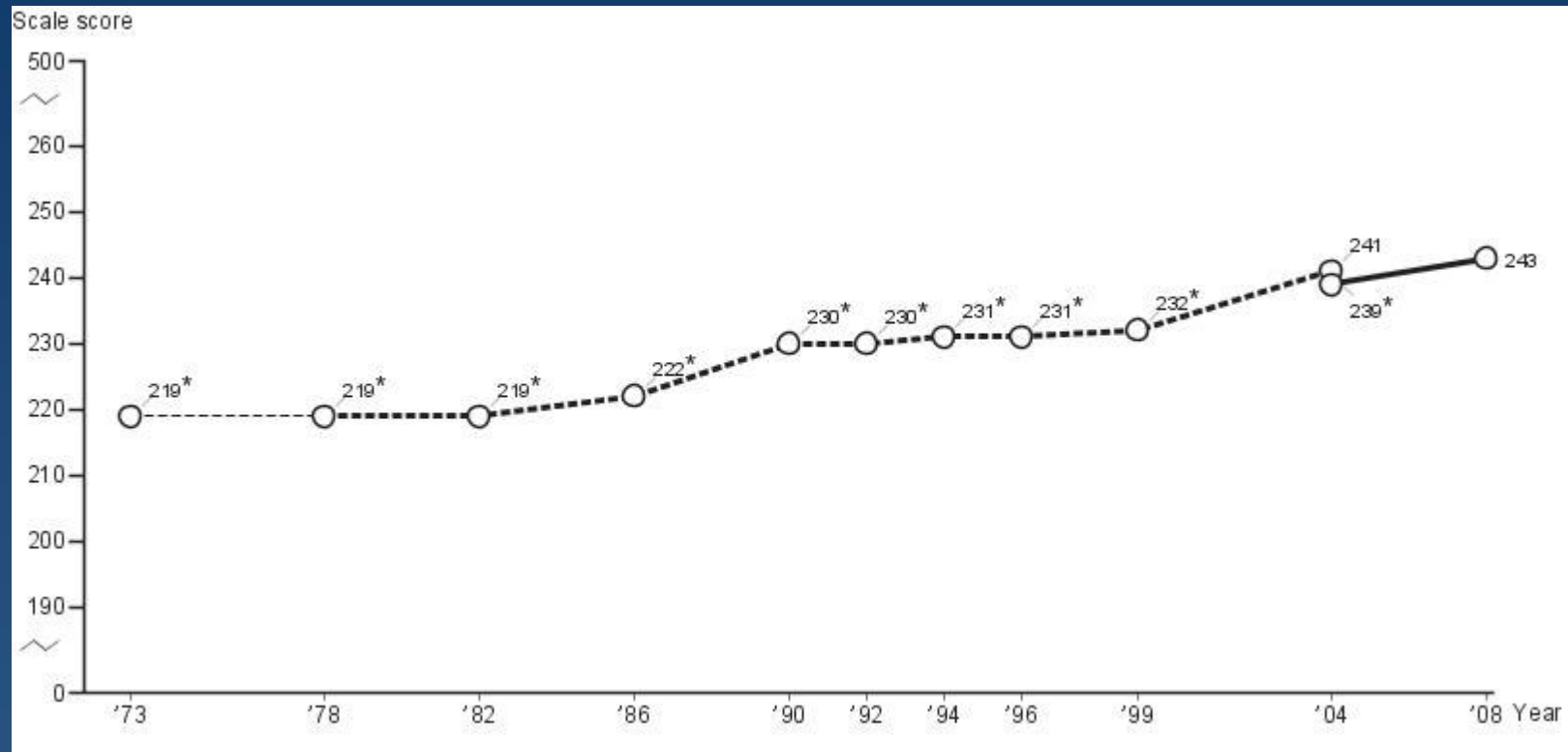
- Sadler and Tai surveyed 8,474 students enrolled in introductory science courses at 63 randomly selected four-year colleges and universities across the U.S. The students reported on their high school coursework (0, 1, or 2 years) in biology, chemistry, physics, and mathematics
- High school coursework in one of the sciences generally does not predict better college performance in other scientific disciplines. But **students with the most rigorous high school preparation in mathematics** perform significantly better in college courses in biology, chemistry, and physics.

## Bachelor's degree attainment rate by highest level of mathematics reached in high school by 1992 12th-graders

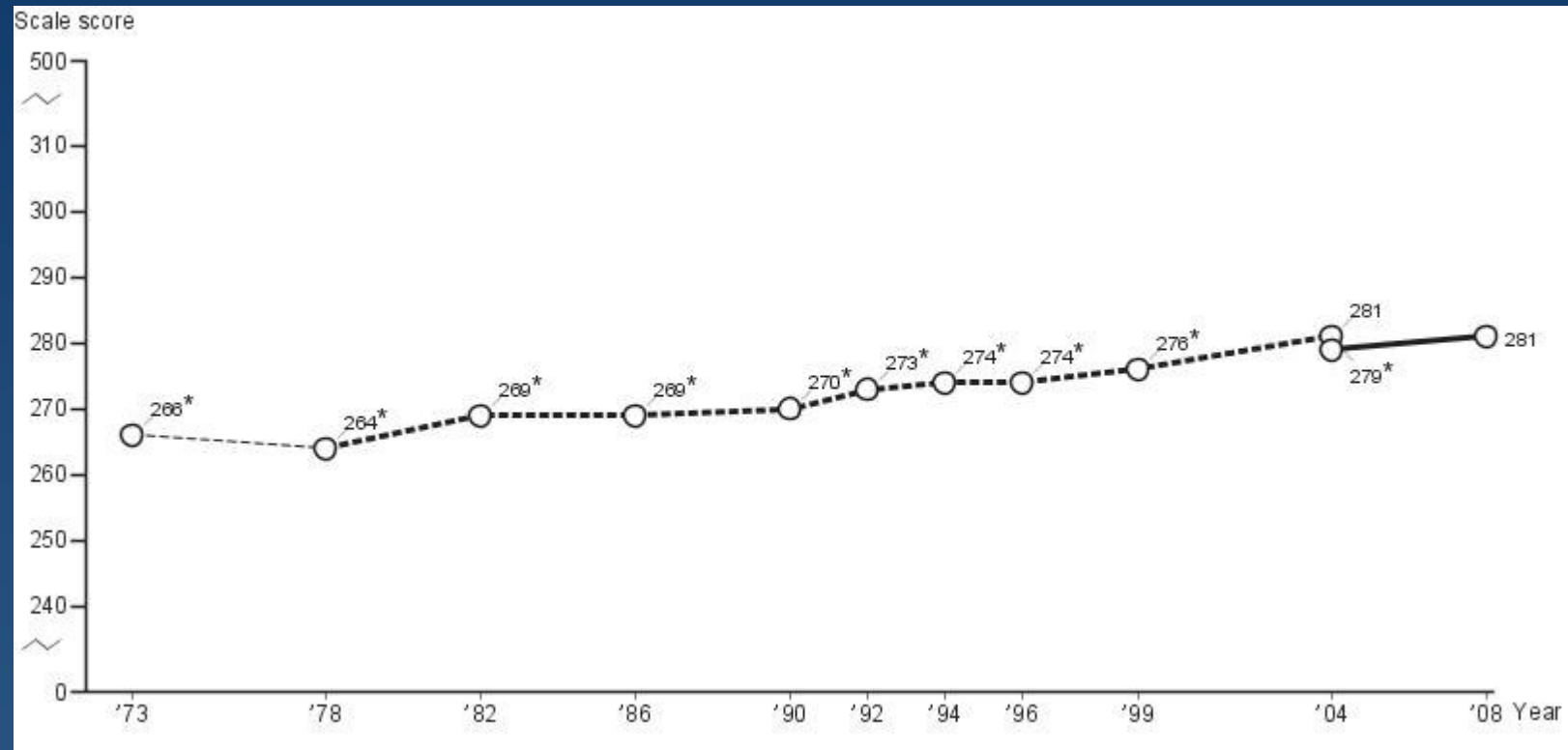
Level of math	Earned Bachelor's
Calculus	83
Pre-calculus	75
Trigonometry	60
Algebra 2	39
Geometry	17
Algebra 1	7
Pre-algebra	4

How are we doing in mathematics

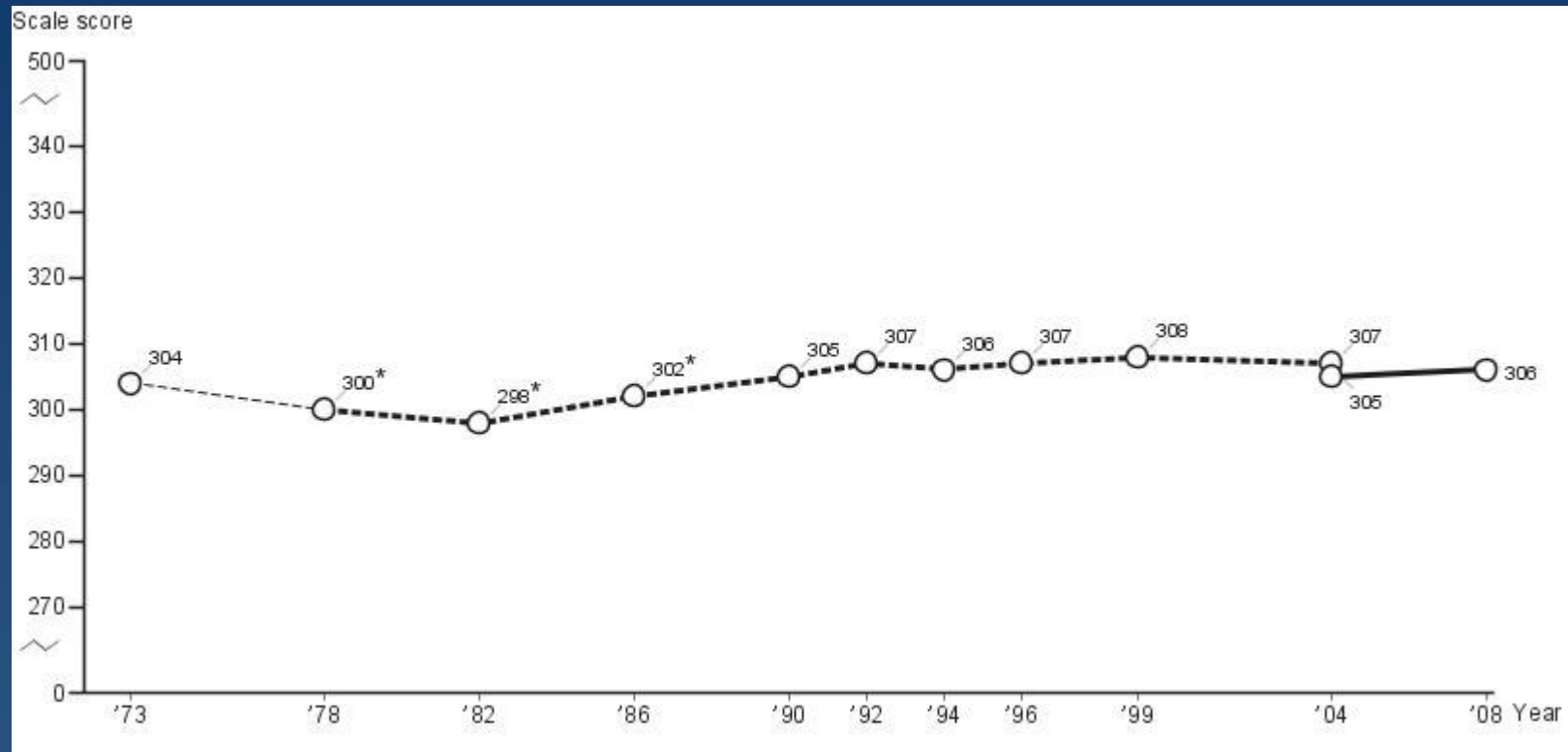
# NAEP LTT Math 9-year-olds



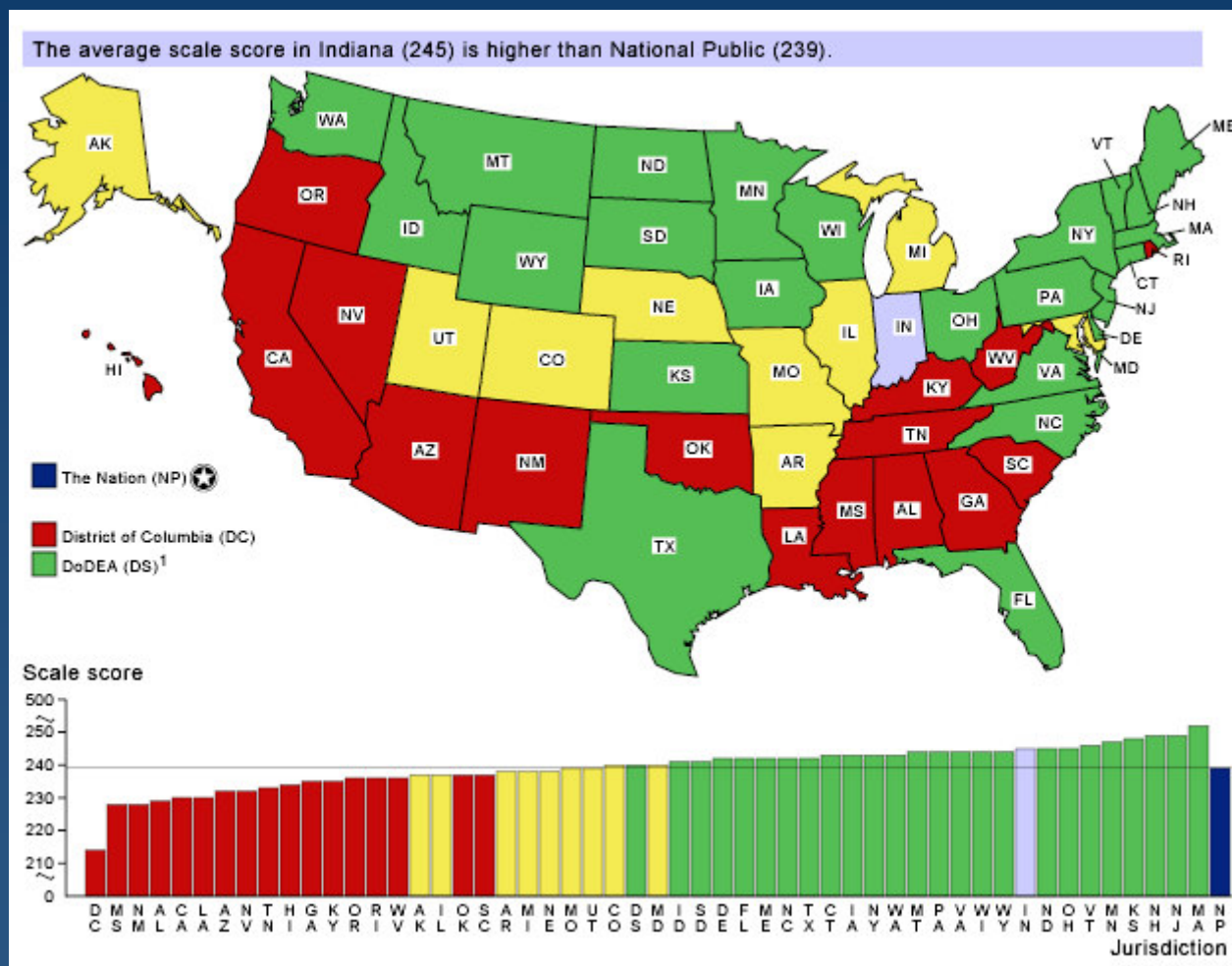
# NAEP LTT Math 13-year-olds



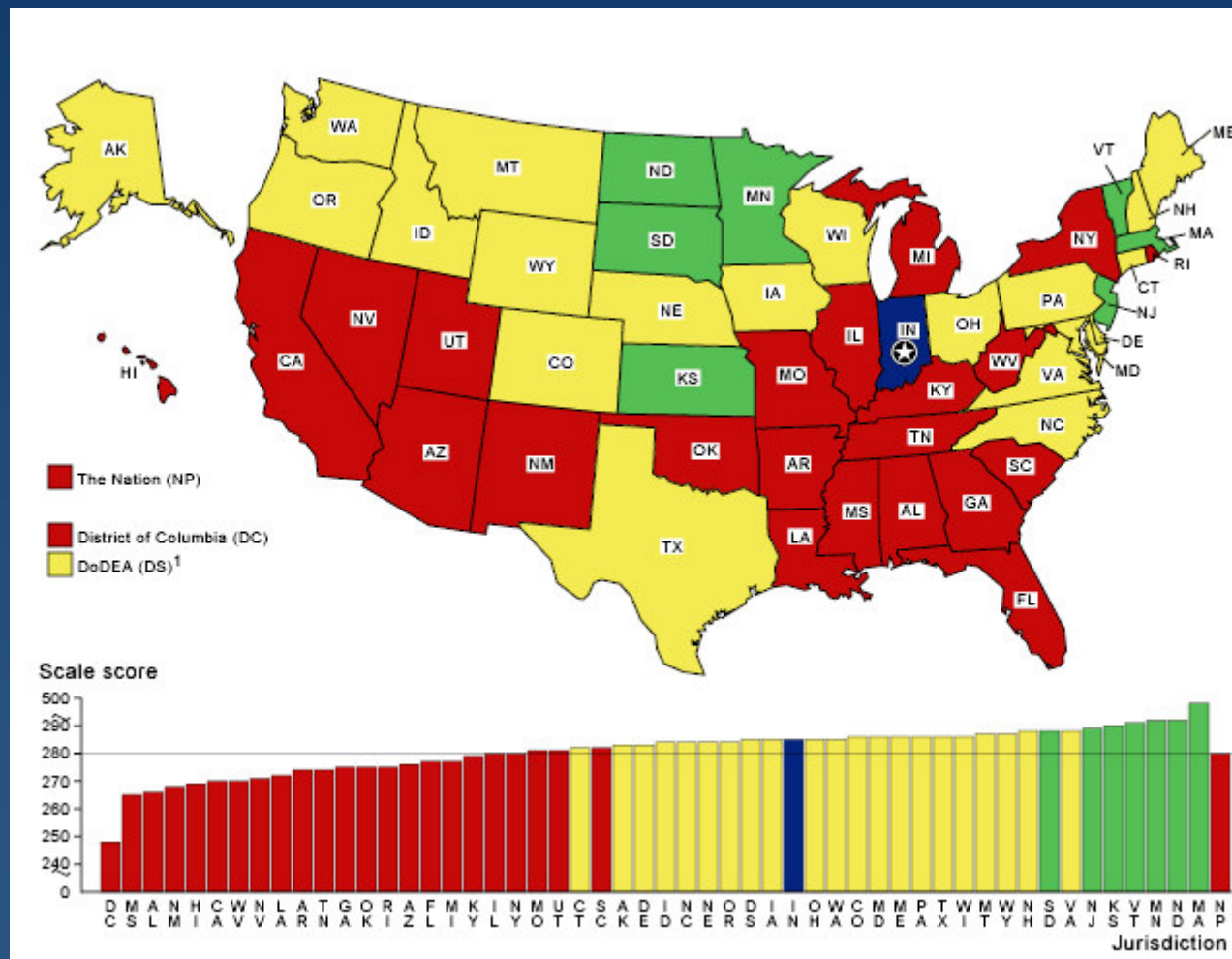
# NAEP LTT Math 17-year-olds



# How does Indiana perform on NAEP math at 4<sup>th</sup> grade?



# How does Indiana perform on NAEP math at 8<sup>th</sup> grade?



# TIMSS 2007

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Grade four		Grade eight	
Country	Average score	Country	Average score
TIMSS scale average	500	TIMSS scale average	500
Hong Kong SAR <sup>1</sup>	607	Chinese Taipei	598
Singapore	599	Korea, Rep. of	597
Chinese Taipei	576	Singapore	593
Japan	568	Hong Kong SAR <sup>1,4</sup>	572
Kazakhstan <sup>2</sup>	549	Japan	570
Russian Federation	544	Hungary	517
England	541	England <sup>4</sup>	513
Latvia <sup>2</sup>	537	Russian Federation	512
Netherlands <sup>3</sup>	535	United States <sup>4,5</sup>	508
Lithuania <sup>2</sup>	530	Lithuania <sup>2</sup>	506
United States <sup>4,5</sup>	529	Czech Republic	504
Germany	525	Slovenia	501
Denmark <sup>4</sup>	523	Armenia	499
Australia	516	Australia	496
Hungary	510	Sweden	491
Italy	507	Malta	488
Austria	505	Scotland <sup>4</sup>	487
Sweden	503	Serbia <sup>2,5</sup>	486
Slovenia	502	Italy	480
Armenia	500	Malaysia	474
Slovak Republic	496	Norway	469
Scotland <sup>4</sup>	494	Cyprus	465
New Zealand	492	Bulgaria	464
Czech Republic	486	Israel <sup>7</sup>	463
Norway	473	Ukraine	462
Ukraine	469	Romania	461
Georgia <sup>2</sup>	438	Bosnia and Herzegovina	456
Iran, Islamic Rep. of	402	Lebanon	449
Algeria	378	Thailand	441
Colombia	355	Turkey	432
Morocco	341	Jordan	427
El Salvador	330	Tunisia	420
Tunisia	327	Georgia <sup>2</sup>	410
Kuwait <sup>6</sup>	316	Iran, Islamic Rep. of	403
Qatar	296	Bahrain	398
Yemen	224	Indonesia	397

# Trends in average mathematics scores of fourth- and eighth-grade students, by country: 1995 to 2007

Grade four				Grade eight			
Country	Average score		Difference <sup>1</sup> 2007–1995	Country	Average score		Difference <sup>1</sup> 2007–1995
	1995	2007			1995	2007	
England	484	541	57*	Colombia	332	380	47*
Hong Kong SAR <sup>2</sup>	557	607	50*	Lithuania <sup>3</sup>	472	506	34*
Slovenia	462	502	40*	Korea, Rep. of	581	597	17*
Latvia <sup>3</sup>	499	537	38*	United States <sup>4,5</sup>	492	508	16*
New Zealand	469	492	23*	England <sup>4</sup>	498	513	16*
Australia	495	516	22*	Slovenia	494	501	7*
Iran, Islamic Rep. of	387	402	15*	Hong Kong SAR <sup>2,4</sup>	569	572	4
United States <sup>4,5</sup>	518	529	11*	Cyprus	468	465	-2
Singapore	590	599	9	Scotland <sup>4</sup>	493	487	-6
Scotland <sup>4</sup>	493	494	1	Hungary	527	517	-10*
Japan	567	568	1	Japan	581	570	-11*
Norway	476	473	-3	Russian Federation	524	512	-12
Hungary	521	510	-12*	Romania	474	461	-12*
Netherlands <sup>6</sup>	549	535	-14*	Australia	509	496	-13*
Austria	531	505	-25*	Iran, Islamic Rep. of	418	403	-15*
Czech Republic	541	486	-54*	Singapore	609	593	-16*
				Norway	498	469	-29*
				Czech Republic	546	504	-42*
				Sweden	540	491	-48*
				Bulgaria	527	464	-63*

# Indiana 4<sup>th</sup> grade



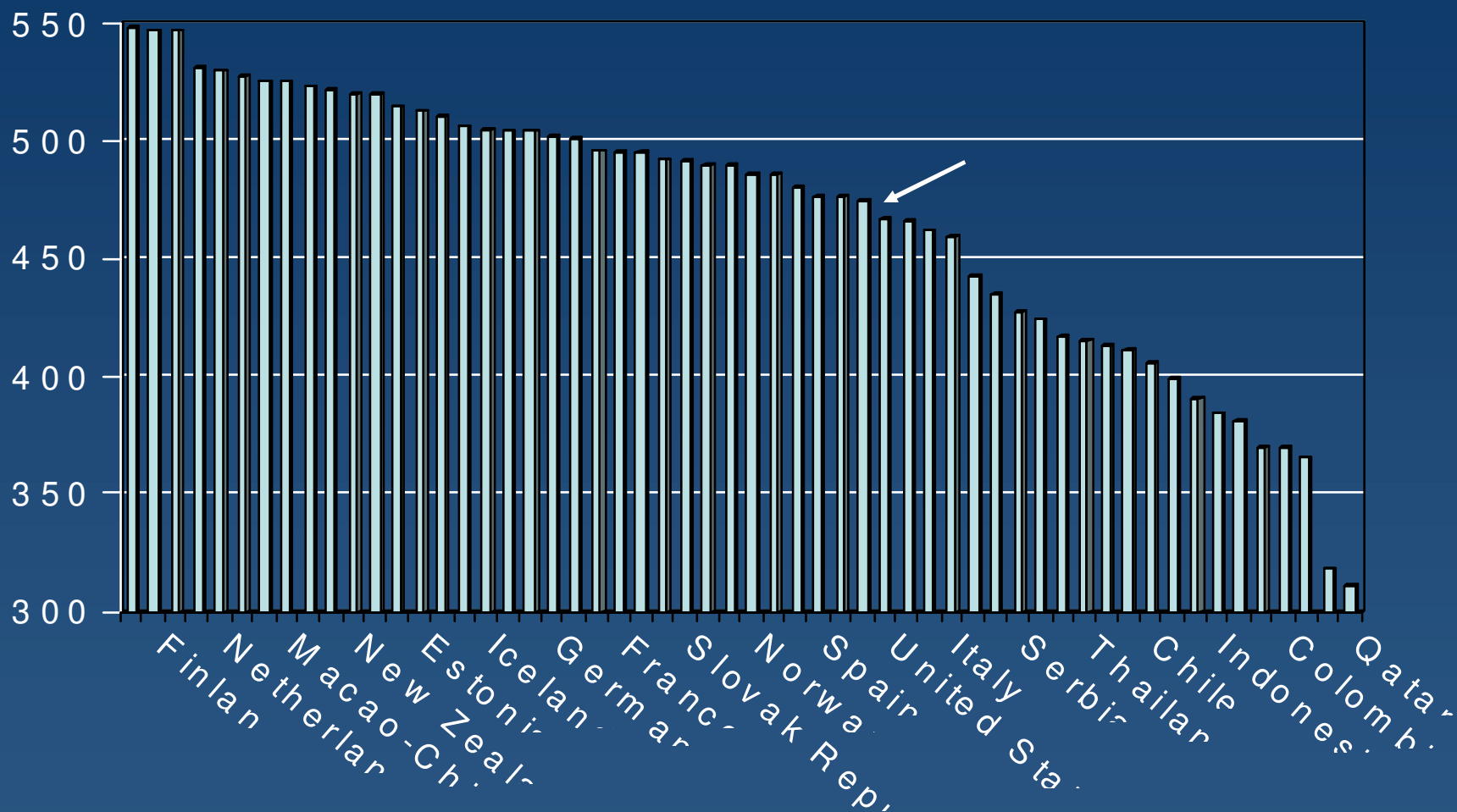
Name	Mean Score	Grade
Hong Kong SAR	607	B+
Singapore	599	B+
C. Taipei	576	B
Japan	568	B
Kazakhstan	549	B-
Russian Federation	544	B-
Indiana	543	C+
England	541	C+
Latvia	537	C+
Netherlands	535	C+
OECD Mean	531	C+
Lithuania	530	C+
U.S.	529	C+
Germany	525	C+
Denmark	523	C+
Australia	516	C+
Hungary	510	C
Italy	507	C
Austria	505	C
Sweden	503	C
Slovenia	502	C
Armenia	500	C
Slovak Republic	496	C
Scotland	494	C
N Zealand	492	C
Czech Rep	486	C
International Mean	482	C

# Indiana 8<sup>th</sup> grade



Name	Mean Score	Grade
C. Taipei	598	B+
Korea, Rep. of	597	B+
Singapore	593	B+
Hong Kong SAR	572	B
Japan	570	B
Hungary	517	C+
Indiana	516	C+
England	513	C+
Russian Federation	512	C
OECD Mean	511	C
U.S.	508	C
Lithuania	506	C
Czech Rep	504	C
Slovenia	501	C
Armenia	499	C
Australia	496	C
Sweden	491	C
Malta	488	C
Scotland	487	C
Serbia	486	C
Italy	480	C
Malaysia	474	C-
Norway	469	D+
Cyprus	465	D+
Bulgaria	464	D+
Israel	463	D+
Ukraine	462	D+
International Mean	461	D+

# PISA Mathematics, 2006



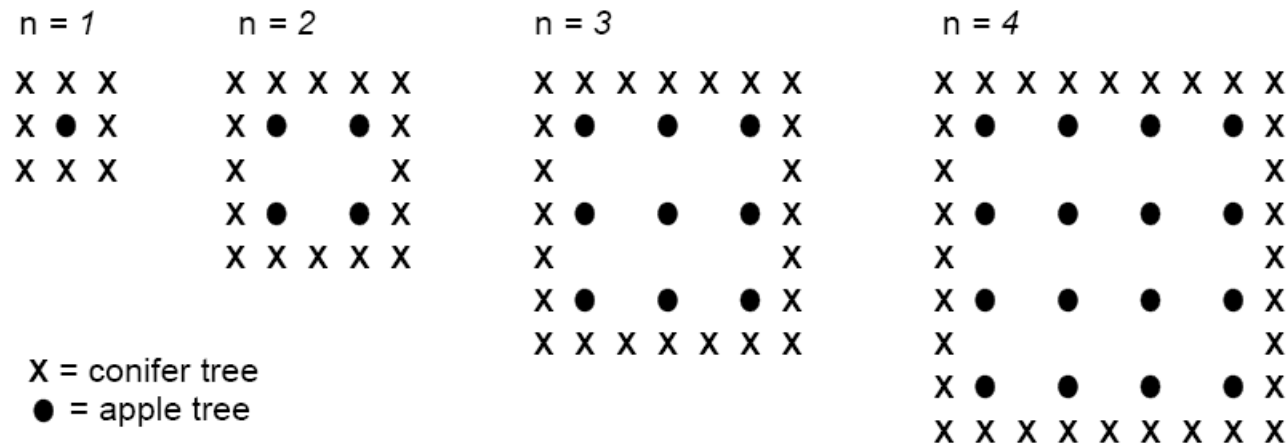
# Why is PISA an outlier?

Questions? Age? Curriculum Alignment?

## PISA example

A farmer plants apple trees in a square pattern. In order to protect the apple trees against the wind he plants conifer trees all around the orchard.

Here you see a diagram of this situation where you can see the pattern of apple trees and conifer trees for any number (n) of rows of apple trees:



# PISA answer

Complete the table:

n	Number of apple trees	Number of conifer trees
1	1	8
2	4	
3		
4		
5		

## APPLES SCORING 1

Complete the table:

n	Number of apple trees	Number of conifer trees
1	1	8
2	4	16
3	9	24
4	16	32
5	25	40

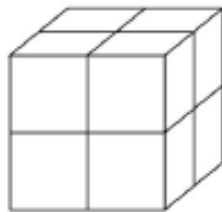
Apple trees =  $n^2$

Conifer trees =  
 $4 (n \times 2)$

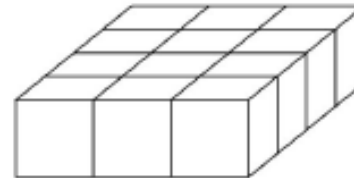
# TIMSS Question and Answer (8<sup>th</sup> grade)

All the small blocks are the same size. Which stack of blocks has a different volume from the others?

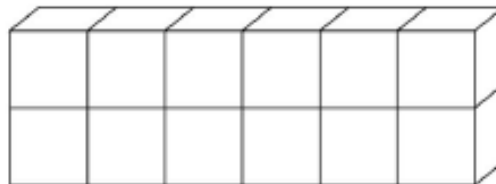
(A)



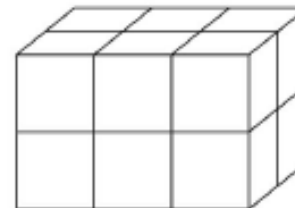
(B)



(C)



(D)



A

# NAEP 17 year old question and answer

If  $f(z) = z + 8$ , what is the value of  $f(6)$  ?

ANSWER: \_\_\_\_\_

(14) 33% of students could not answer

# NAEP 12<sup>th</sup> grade Q & A

The first term in a sequence of numbers is . Each term after the first term is 1 more than twice its previous term. What is the 4th term?

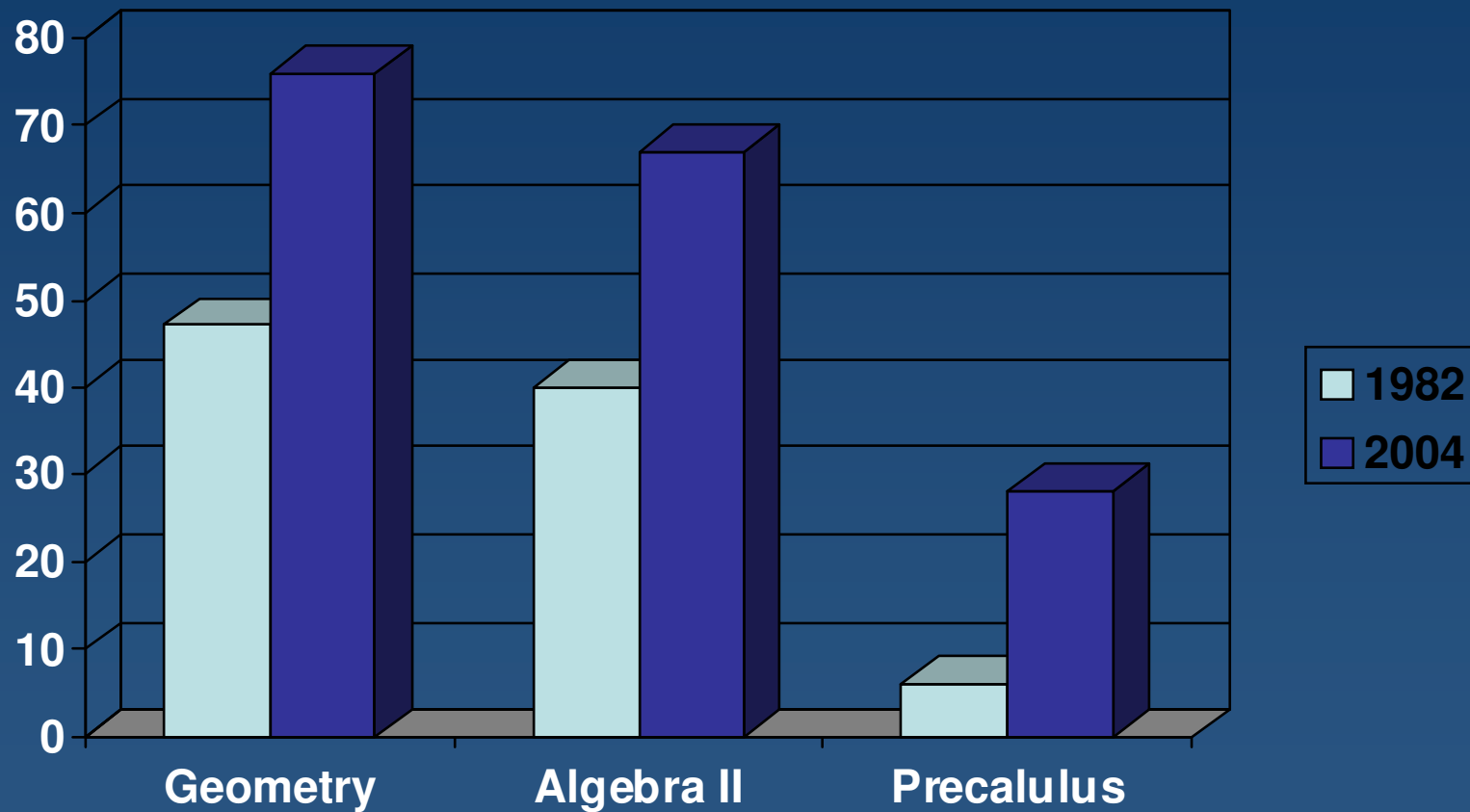
- A) 2
- B) 4
- C) 5
- D) 11 \* (50% could not answer)
- E) 23

The book, not just the cover

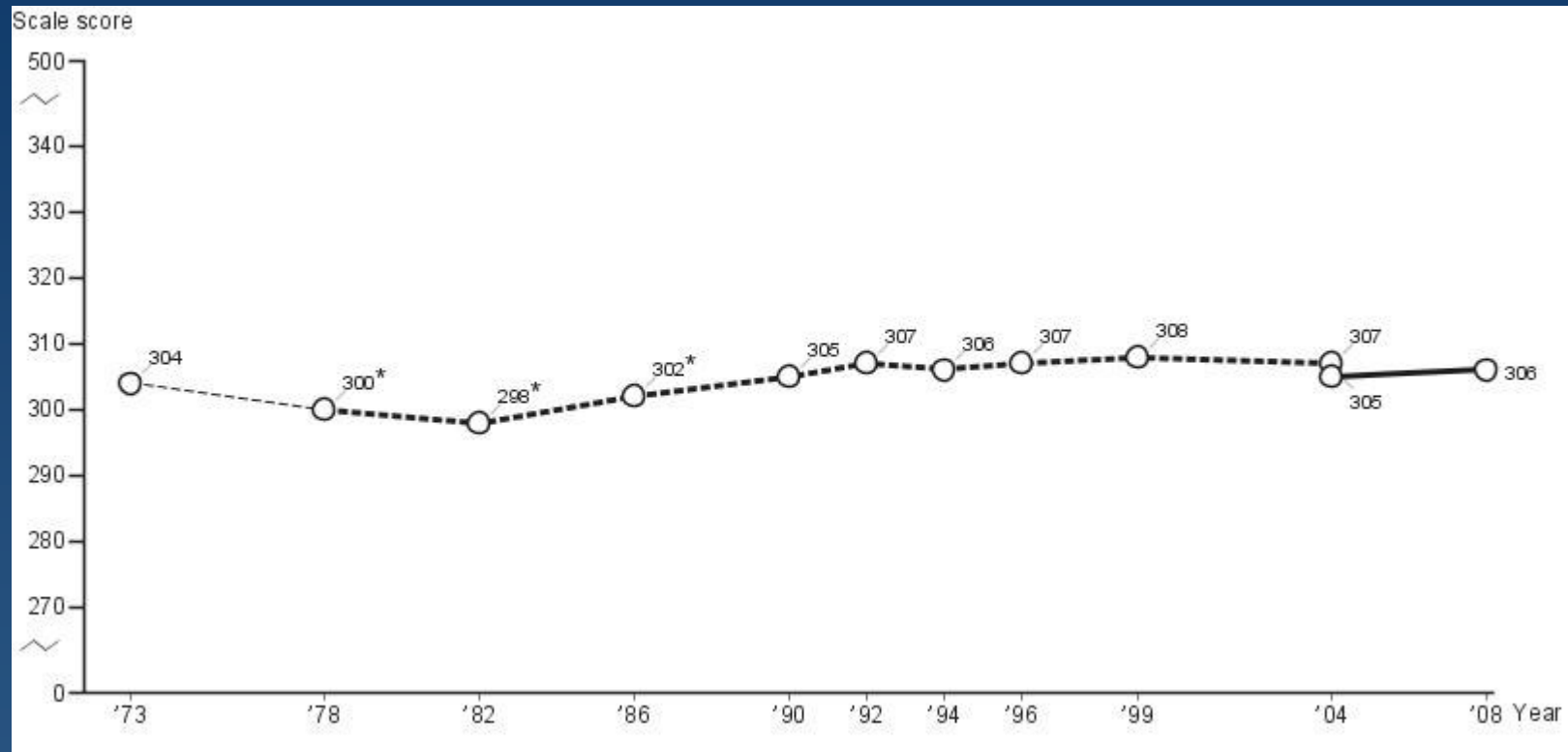
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# Dramatic increases in advanced math course taking in high schools



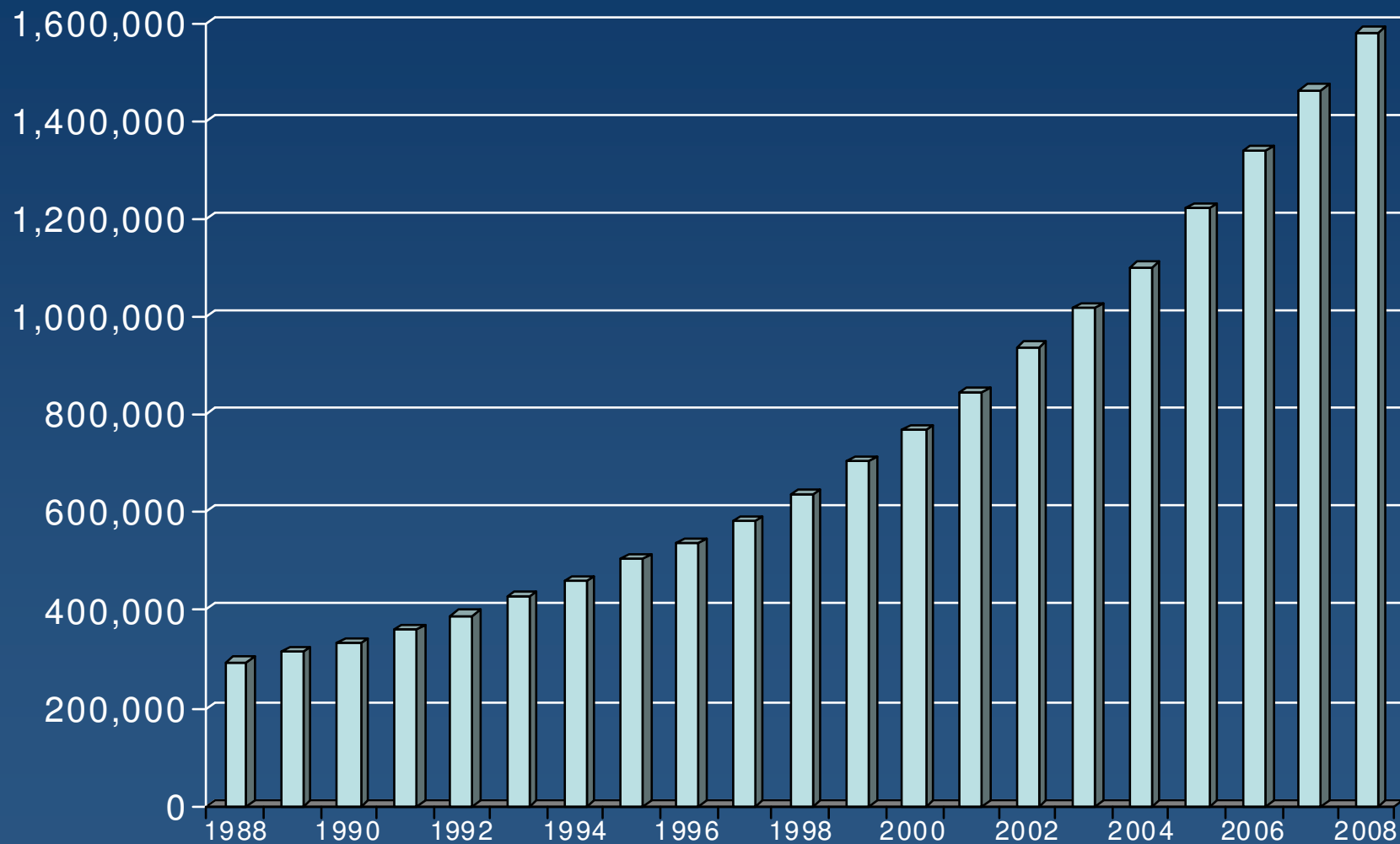
# NAEP LTT Math 17-year-olds



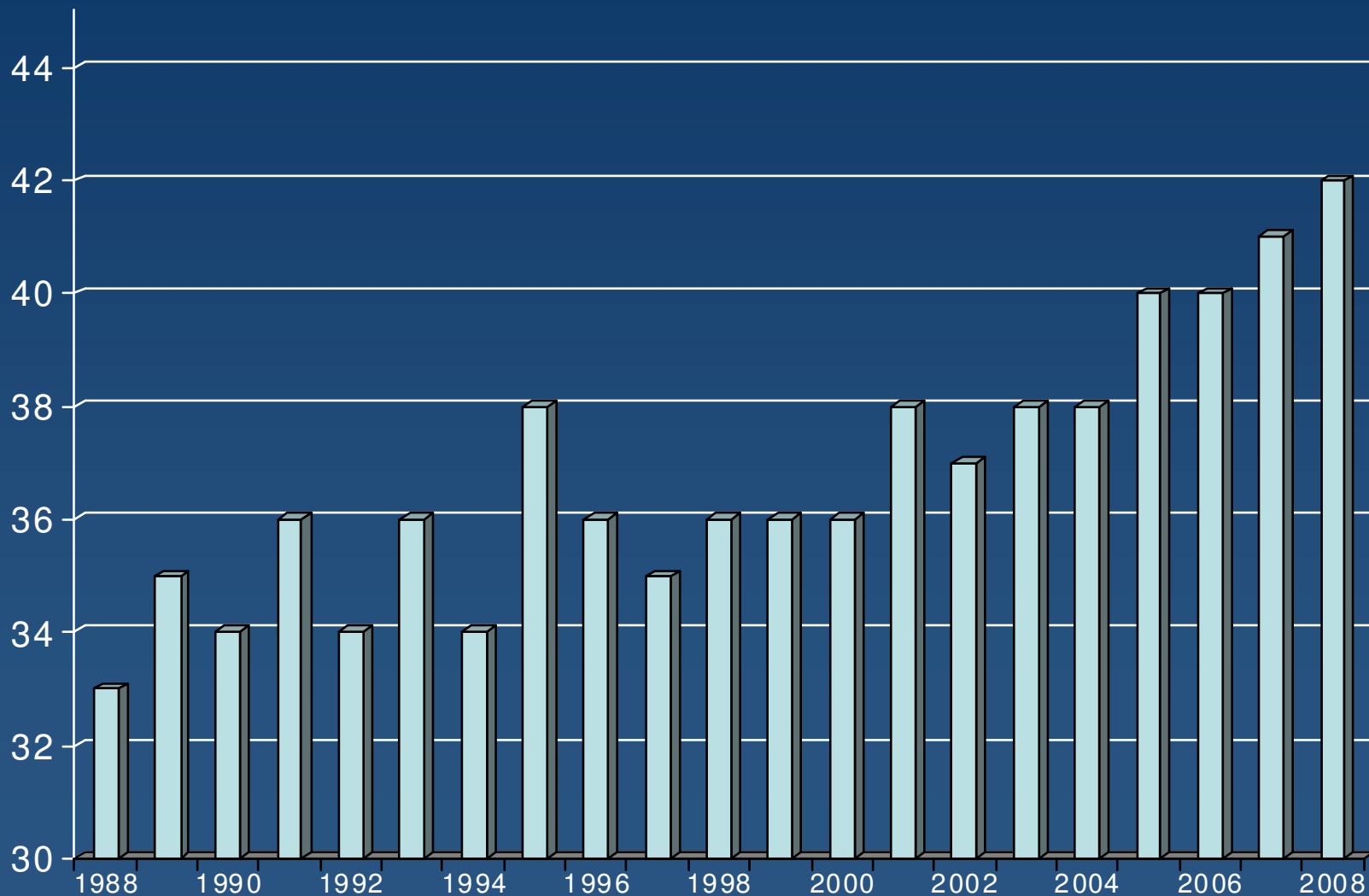
# Grade inflation and/or course deflation

60% of Texas low-income students, 65% of African-American students, and 57% of Hispanics who received course credit for Geometry and Algebra 2 failed a state exit exam covering Geometry and Algebra 1 (Dougherty et al., 2006)

# Number of Students in AP



# % AP Students Failing AP Exam



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# Many AP Students Don't Take the Exam

- The Commission on the Future of the Advanced Placement Program estimated in 2001 that over a third of AP students do not sit for the examinations.
- Based on students who enter public postsecondary institutions within California, about 45% take AP courses but not the exams.
- In Texas the corresponding number is 47%, with another 25% taking AP courses but failing the exam. Thus 72% of college-goers in Texas public institutions with AP experience have not demonstrated college-level knowledge of the content of their AP coursework.

# Is it content learned or course taken?

- Geiser and Santelices (2004): Number of AP courses failed to predict either undergraduate grade point average or dropping out at UC whereas students' scores on the AP did
- Sadler and Tai (2007): AP exam scores predict college science grades. Students with failing AP did no better than students who had not taken AP.
- Adelman (2006): No statistical relationship between the number of AP courses taken by high school students and college graduation in a nationally representative sample.
- Klopfenstein and Thomas (2009): No evidence in Texas that AP course-taking increases the likelihood of early college success regardless of race or family income.
- Dougherty et al. (2006): Benefit to college graduation rates that TX schools obtain from enrolling more students in AP courses is tied to the percent of the school's overall population who are able to pass AP exams.

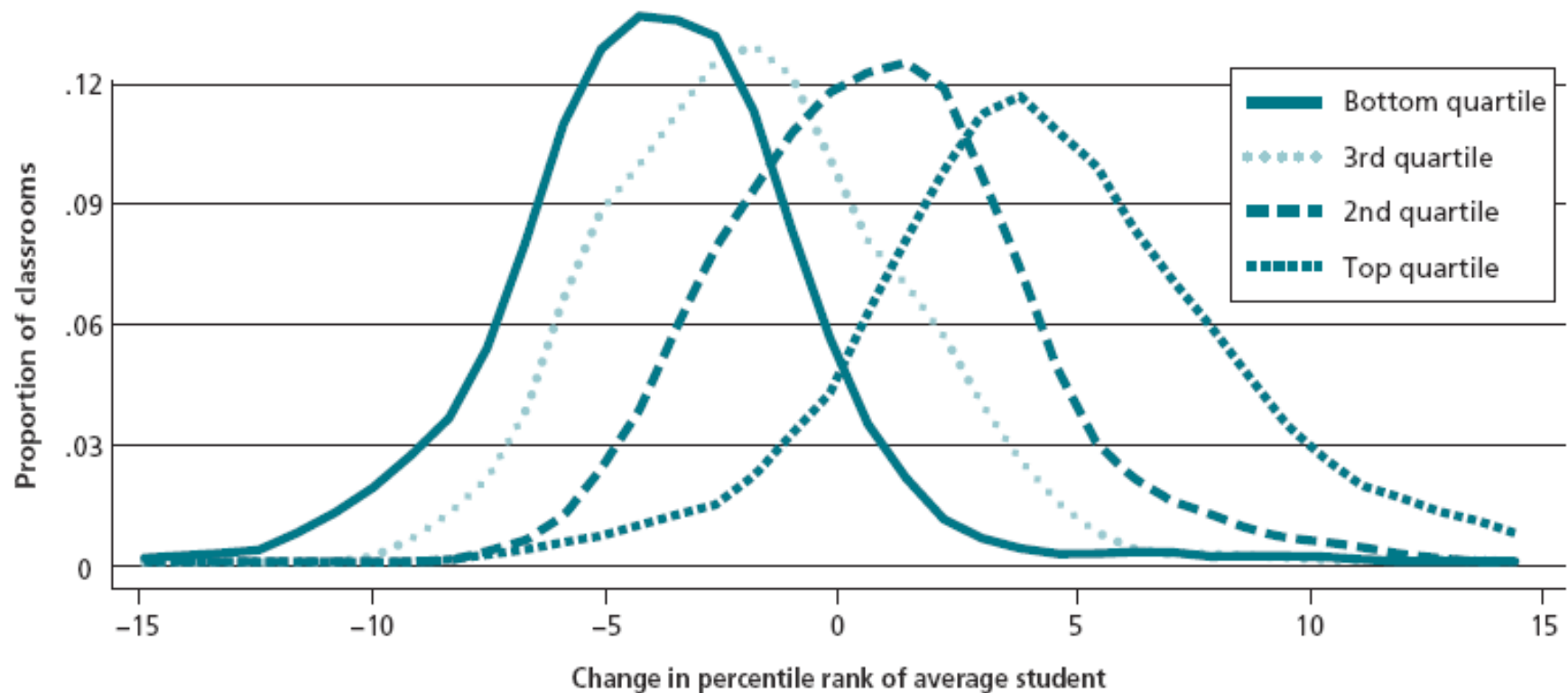
# How to enhance math achievement

# Challenging Content

- Appropriate standards
- Adequate preparation
- Aligned, high stakes assessments

# Effective teachers

Figure 2. Teacher Impacts on Math Performance in Third Year By Ranking after First Two Years



Note: Classroom-level impacts on average student performance, controlling for baseline scores, student demographics, and program participation. LAUSD elementary teachers, < 4 years' experience.

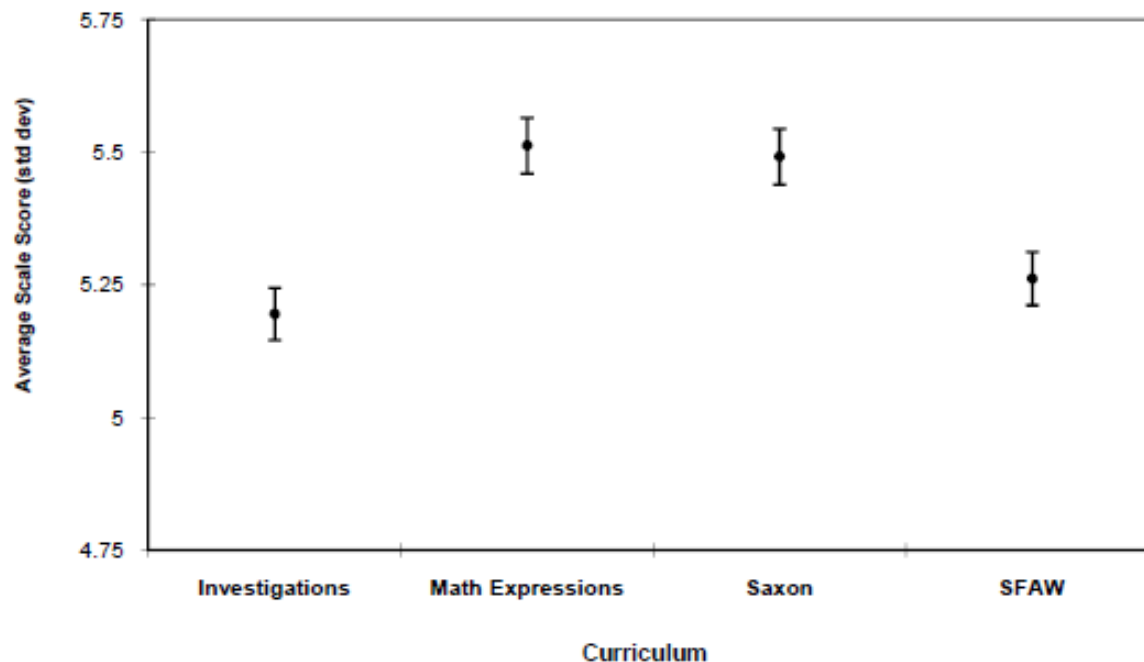
# Effective schools

- New York (Hoxby)  
Math ES = 0.09  
Reading ES = 0.04
- Boston (Kane et al.)  
Math ES = 0.54 (middle school) 0.19 (high school)  
Reading ES = 0.17 (middle school) 0.16 (high sch)
- Harlem Children's Zone Promise Academy

Middle-School Lottery Results (pooled sample)		
Dependent Variable	ITT	TOT
6th Grade Math Score	0.225***	0.342***
7th Grade Math Score	0.313***	0.468***
8th Grade Math Score	0.733***	1.112***
6th Grade ELA Score	0.024	0.037
7th Grade ELA Score	0.039	0.058
8th Grade ELA Score	0.239***	0.363***

# Effective curriculum

Average HLM-Adjusted Spring Math Score with Confidence Interval, by Curriculum  
(in standard deviations)



Note: The dots in each symbol represent the average HLM-adjusted spring math score (in standard deviations) for each curriculum, and the bars that extend from each dot represent the 95 percent confidence interval around each average. Curricula with non-overlapping confidence intervals have significantly different average scores at the 5 percent level of confidence.

Average HLM-adjusted spring math achievement of Math Expressions and Saxon students was 0.30 standard deviations higher than Investigations students, and 0.24 standard deviations higher than SFAW students.

# Summary

- The U.S. has fallen behind in educational attainment
- Postsecondary educational attainment is a strong driver of prosperity
- Mathematics achievement at the secondary level is a uniquely strong predictor of college success
- The U.S. has improved substantially in mathematics achievement at the elementary and middle school level but is stagnant at the high school
- U.S. students compete well internationally on the delivered curriculum but less well on problem solving

# Summary (continued)

- Substantial increases in the apparent rigor of the mathematics curriculum do not reflect increased student learning
- Key levers for enhancing mathematics achievement include:
  - 1) Appropriate standards, student prep, and high stakes assessments
  - 2) Effective teachers
  - 3) Effective schools
  - 4) Effective curriculum